An Evaluation of Virtual Representations of Transit Agencies: Are Internet Sites of Transit Agencies Functions of Their Physical Attributes?

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Executive Summary

The purpose of this study is to identify the association between virtual representations and physical attributes of transit agencies. For this study, data including information about Internet sites and physical attributes of transit agencies were obtained from the National Transit Database (NTD) for the year 2000. Then, transit agencies were sampled from the data using a stratified sampling technique from which inferences were drawn for large, medium, and small agencies.

Based on theoretical and practical considerations regarding the provision of information, this study develops a rating instrument for evaluating Internet sites of transit agencies. Then, the association between the results of the evaluation and physical characteristics of transit agencies is investigated.

The evaluation results suggest that transit agency size, measured in terms of ridership, plays a key role in determining how information is disseminated to the user and the quality of such information dissemination efforts. The results indicate that beyond a certain agency size there appear to be diseconomies of scale in the quality of transit information provided via the Internet. In particular, medium-sized agencies' Internet sites received the highest scores in the quality of map, schedule, and trip planner; as the size of transit agency increases, the quality of information also increases. However, after a certain agency size, the degree of complexity of transit system may be too high, thus the information may not be easily presented through Internet sites. Therefore, the overall quality of the information in large agencies is rated lower than medium agencies.

While diseconomies of scale are detected in the quality of other important transit information such as map and schedule, large agencies received the highest scores in the design aspects of Internet site: the prior knowledge requirement and readability. This means that large agencies have made endeavors to make their sites more usable and processable to reduce users' cognitive costs. This may be because it is critical for large agencies to provide a high quality design in order to sort out the large amount of information sought by the user, while presenting the information itself may be difficult.

Another finding indicates that large agencies provide information search functions to reduce cognitive costs of users; large agencies are more likely to provide trip planners and search functions than medium and small agencies. This is interpreted that since Internet sites of large agencies contain a large amount of information, it may be difficult for users to locate particular information they want; thus, those agencies attempt to assist users finding information they need by providing advanced information searching tools.

On the other hand, medium and small agencies help transit users to find information by offering person-to-person assistance or links to other sites containing relevant information. However, these strategies may be less feasible for large agencies, since those agencies are likely to maintain a large amount of information in their sites and accommodate a large number of transit riders; thus, it may be difficult for large agencies to provide one-on-one attention to users.

The results of statistical models indicate that the relationship between information quality/presence and physical attributes are not biased by the presence of Internet sites of transit agencies. However, the models confirm the previous findings: diseconomies of scale in presenting information for large transit agencies. That the results are supportive of the hypothesis of diseconomies of scale is an important finding of this study. Unfortunately, the current data are not appropriate to fully test this hypothesis, but the findings are consistent with what the hypothesis indicates. Future research should apply more standard techniques to test for the presence of such potential diseconomies of scale.

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1. Introduction

Currently, more than half of all American adults have access to the Internet and the proportion of American households with home computers reached 56 percent in 2001, up from 37 percent in 1997, and 15 percent in 1989 (Schaller, 2002). Use of the Internet as a mean for representing organizations and providing information around the world has also grown substantially over the last decade. This growth is attributable to several factors, including improved access for information seekers and low start-up costs for information providers. Among these information providers are a large number of transit agencies that have recognized that an Internet site can be useful for representing the agencies and providing information to transit users.

A number of studies have suggested that since transit systems are composed of numerous elements including physical geography, landmarks, connections, and rules, the Internet can provide a unique opportunity to convey those elements in an integrated and interactive form (Schaller, 2002; Kenyon et al, 2002; and Volpe National Transportation Systems Center, 2001). Moreover, the Internet provides transit agencies with the ability to present their information dynamically. Thus, the Internet appears to be a valuable medium through which the dissemination of integrated transit system components can occur. In many ways, sites are virtual transit agencies. Data reported in the National Transit Database (NTD) suggest that 67 percent of transit agencies have Internet sites. Furthermore, between 8 to 20 percent of all transit users have visited their transit agency's Internet site and growth in site usage continues to outpace the growth in the overall number of Internet users, growing by 30 to 100 percent annually (Schaller, 2002).

Aside from developing Internet sites to provide information to existing and potential customers, transit agencies continue to serve their traditional functions. Agencies operate their transit systems with tangible and physical elements including vehicles, routes, schedules, stations and passengers. Also, because each transit agency serves a geographically or culturally unique area, transit agencies have different service characteristics such as operating budgets, annual vehicle miles, passenger miles, and ridership. These physical characteristics also reflect resource constraints on agencies.

Since the Internet has been actively used for only a decade or so, so far there are no studies available which relate the transit agency's virtual locale with the physical characteristics of the service the agency provides and evaluate them with respect to the particular way of representation. However, numerous questions exist regarding virtual and physical characteristics of transit agencies: is transit information contained in Internet sites related or unrelated to the way transit agencies operate? For example, do transit agencies with large operating budgets have higher quality map and schedule information on their Internet sites? Are virtual representations of transit agencies functions of their physical service attributes?

This study attempts to evaluate transit agencies' Internet sites and correlate to physical transit service characteristics. A tool for evaluating transit Internet sites - a rating instrument - is developed based on a number of criteria in Section 3. In identifying the criteria for evaluating transit Internet sites, we rely on theoretical and practical considerations regarding the provision of information. Section 3.1 reviews the research studies with respect to theoretical bases for searching information and presents the implications for transit Internet sites. Section 3.2 investigates practical guidance for evaluating Internet sites. From this section, the criteria for Internet site evaluation include design, functionality, accessibility, and contents.

Section 4 deals with data used in the study. Data including information about Internet sites and physical attributes of the agencies were obtained from National Transit Database (NTD) for the year 2000. Transit agencies were sampled from the data using a stratified sampling technique, allowing us to draw inferences for large, medium, and small agencies.

Section 5 analyzes the results from the evaluation tool that compares physical attributes of transit agencies to the agencies' Internet sites in terms of agency size. Also, this study attempts to draw an association between transit agencies' physical attributes and transit information in their Internet sites using a regression model. The statistical model may point toward more specific relationships between key transit service attributes and the information on their Internet sites.

2. Place Marketing, Internet Site and Transit Agency

The representation of transit agencies and provision of transit information through Internet sites may be an effective strategy to promote transit systems. However, there have been no studies with respect to what motivates transit agencies to develop Internet sites. There are several references in the literature that may suggest the reason why local governments virtually represent themselves through Internet sites.

In the 1970s context of urban crisis, city politicians began to reconsider their traditional local policies and attempted to adopt an entrepreneurial strategy to promote their cities. Several researchers investigated the definition and extent of place marketing, suggesting that local municipalities responded the dynamic changes by adopting place marketing strategies (Ashworth and Voogd, 1990; Law, 1993; Fretter, 1993; Sadler, 1993; Duffy, 1995; Holcomb, 1999).

The marketing of places was becoming a big business in the mid-1970s and, importantly, pointed out the difference between selling and marketing (Fretter, 1993). While selling only tries to get the customer to buy what you have, marketing is a broader concept in that it tries to meet customer needs profitably. Thus, place marketing is not just selling the area to attract companies or tourists and it should be viewed as a fundamental part of planning and guiding the development of places (Fretter, 1993). Sadler (1993) used the term; 'place promotion' as the marketing of a city to obtain a greater share of limited national and international wealth. Urban (2002) supported Sadler (1993) by suggesting that the competition between different cities was further increased for the last three decades as economic globalization and the flexibility of international capital flows increased.

Urban (2002) conducted a study to see how cities promote and market place by virtually representing themselves on Internet sites. Urban's study compared twenty official city Internet sites to their sizes of agglomeration, wealth level of their respective countries, and status as a World City[1]. By examining the contents and size of city Internet sites, the study attempted to correlate these Internet site attributes with the characteristics of the cities. While the author discovered a clear correlation between the wealth level of the country and the size of the Internet site, the analysis showed that city size, global significance and economic performance did not sufficiently explain the structure and characteristics of Internet sites.

Several researchers made a connection between place marketing and building images of places. Ashworth and Voogd (1990) suggested that public authorities have

[1] According to Urban (2002), World City status is defined by the level of financial, service, information network, and international significance as economic or political center (Fridmann and Wollff, 1982; Friedmann, 1986; Sassen, 1994). .

changed attitudes toward the role of planning within a market and adopted marketing strategies to promote and market their cities. The authors also indicated that images of place play a major role for people to decide where they live, work, invest or recreate, thus, image building is a widely used tool for intervening markets. Places are marketed through their generalized images, since the goods and services in the city are difficult to specify. "A place can only be commodified …. by means of a rigorous selection from its many characteristics…….. the results of this selection is the place-image." (Ashworth and Voogd, 1990) It is argued that due to the intrinsic complexity of places, it is impossible to be aware of all place attributes and uses; thus, image building is critical and widely used for intervening in markets (Ashworth and Voogd, 1990).

In this regard, Urban's (2002) statement "the existence of a virtual town-hall and a virtual marketplace is a statement, which defines a city in a particular way and which can be seen in relation to entrepreneurial strategies" may be interpreted as that representing cities in Internet sites is a way of building images of cities, which may 'define a city in a particular way.'

In transit contexts, the main objective of developing Internet sites may be to provide transit information to users. However, transit agencies may have used Internet sites to build positive images of their transit systems. Just as a city has 'the intrinsic complexity and services are difficult to specify' (Ashworth and Voogd, 1990), transit is also a complicated system with various elements such as geography, time, and connections. Thus, it is not likely that transit users are aware of all attributes of a transit system. Perhaps the system can only be 'sold' through generalized and selected positive images. In this respect, transit agencies building Internet sites can be translated into adopting a marketing strategy for building positive images thereby, promoting their transit systems.

This marketing strategy for transit systems can be further extended as an approach to compete with other transportation modes; it is linked to place promotion strategy for encouraging city tourism. Because a place is usually 'sold' to tourists before they see it, place-marketing strategies are important for encouraging urban tourism. That is, since the product (a place) cannot be tested and compared to similar products, marketing is intrinsically significant for encouraging tourism (Holcomb, 1999). Holcomb (1999) suggested that as tourism has become one of the vital strategies for urban regeneration, local governments have invested a greater amount of resources to 'sell' the city to potential tourists. The author indicated that the 'perceived appeal as places for play' of cities is a key for attracting tourists. In this respect, the virtual representation of a city in the Internet site can be interpreted as a particular form of place marketing to tourists. This is supported by Law (1993) to some extent, suggesting that people want to visit places, as a result of learning from media that construct potent images of places.

Similar to tourists choosing which city they will visit based on their recognized images of a city as a place for recreation, people who have various transportation mode choices will choose transit if their perceived images of transit systems are more attractive and positive than other modes. This is particularly important in that public transportation in general has not been the dominant transportation mode in the United States[2]. Accordingly, transit agencies may desire to appeal choice riders to take transit and effective strategies to attract choice riders to transit may include a virtual representation of their systems and disseminating the information through Internet sites.

[2] Hu and Young (1992) indicated that 94% of all-purpose trips were automobile based.

Furthermore, a positive image of transit may be even more critical, since a number of transit systems have suffered from stigma.

In sum, although transit agencies' Internet sites provide practical transit information to a number of users, agencies may also feel a great need for representing themselves and disseminating transit information as an entrepreneurial strategy for promoting and selling their transit systems. Internet sites can contribute to transit agencies in building positive images to promote their systems. Building a generalized positive image is a key, since transit is a complicated system and composed of various elements.

Moreover, knowing that public transit is not a dominant transportation mode in the United States, transit agencies may be forced to encourage patronage of their systems to compete with other modes and raise revenues from transit users. Thus, transit agencies represent their systems and provide transit information through Internet sites as a strategy to attract choice riders to take transit.

3. Evaluating Transit Information

From this paper, a tool was developed for evaluating the quality of transit Internet sites and transit information as well as the existence of Internet sites and certain types of information. Although Urban (2002) investigated the size of Internet sites and the presence of certain features, it did not measure the quality of information and it did not attempt to correlate the quality with physical elements of cities. Measuring the quality of information and Internet sites may be critical for evaluating transit agencies' virtual locales, since information quality plays a key role in building a positive image of the transit system with a final goal of increasing transit use.

As previously mentioned, the rating instrument for evaluating transit Internet sites was developed based on Internet site evaluation criteria studied in transit and non-transit fields as well as economic theories regarding information search. In developing the tool, this paper considered the findings of past studies that have dealt with theories and practical guidance for evaluating Internet sites in general, and considered the findings of research studies. The next two sections provide two major bases for developing criteria through a literature review.

3. 1 Theoretical Background for Evaluating Transit Information

In principle, providing transit information is expected to reduce a traveler's costs of searching and using transit information, thereby lowering the disutility of using transit and resulting in an increase in transit use. Many economists have conducted studies regarding the costs of gathering and using information. In theory, transit agencies Internet sites can reduce transit users' search costs and cognitive costs.

The basic argument behind the theory of search costs is that consumers will continue to search information until the marginal cost of searching information equals the marginal benefit from the obtained additional information (Stigler, 1961). Stigler (1961) indicated that non-monetary costs of searching information are usually time, inconvenience and the difficulty in carrying out the search activity. In the context of the Internet, several researchers suggested that the provision of information through Internet sites can lower those costs in general (Alba et al, 1997; Lynch and Ariely, 2000).

However, the fact that information is available does not guarantee that transit users can actually take advantage of information. Russo (1977) argued that making information available is not sufficient to change consumer behavior; the information has to be processable. That is, the cognitive cost - the cost of making a decision within a given set of information - should be reduced. If transit information is provided through Internet sites to decrease search costs, cognitive costs can be diminished by presenting good quality information. Moreover, cognitive costs for transit users can be further decreased by providing a usable site design that is easy to use and follow. Appendix 1 provides both schools of thought and their implications for transit information.

While both costs are constraints in seeking transit information in general, transit agencies tend to reduce cognitive costs for regular transit users as well as minimize search costs for infrequent transit users and tourists. Regular transit users may want to reduce cognitive costs more than search costs, because they are likely to have a familiarity with the transit system; thus, they may tend to search for specific information in Internet sites. On the contrary, because infrequent transit users or tourists are not familiar with transit systems, they may be more inclined to see what transit information is available in the Internet sites rather than to seek specific information.

There is a study showing that Internet sites should consider both frequent and infrequent transit users in providing information. Gildea and Sheikh (1996) surveyed transit operators in the San Francisco Bay Area and found that 55 percent of Internet site users are just browsing the site (infrequent transit users), whereas 45 percent are looking for specific information on the sites (regular transit users). This finding implies that Internet sites serve as a reference for particular information for frequent transit users as well as a general guide of transit services for infrequent transit users or tourists[3]. Because of this distinction, the evaluation tool reflects both cognitive and search costs

[3] However, the unique characteristics of the study area may have attracted a number of tourists.

and this study attempts to see if transit agencies have tried to reduce both of these costs in providing transit information through their Internet sites.

In sum, the Internet sites of transit agencies are expected to reduce search costs and cognitive costs, which are important for both frequent and infrequent transit users. Therefore, the criteria for evaluating transit agencies' Internet sites should indicate how much cognitive and search costs can be reduced by the use of Internet sites. These measures will be included in the evaluation tool as a theoretical base of evaluating Internet sites.

3.2 Internet Sites Evaluation Criteria

While theoretical aspects regarding transit information should be reflected in the Internet site evaluation tool, practical aspects of Internet sites and transit information are also critical in evaluating Internet sites.

Non-Transit Sources

Several studies that are not related to transit have produced criteria to evaluate Internet sites, among which Grassian (2000) stresses appropriate and comprehensive content and functional structure, and the Oregon Public Education Network (1998) emphasizes user-friendliness, courtesy, and aesthetic appeal. In his account of evaluation criteria, Smith (1997) accentuates accuracy, currency, and quality of content provided; graphic and multimedia design; and workability, specifically user-friendliness, required in the computing environment. Additionally, Alexander (1999) devotes a chapter in his book *Web Wisdom: How to Evaluate and Create Information Quality on the Web* to informational Internet sites and stresses the importance of accuracy, currency, coverage, and knowing the intended audience.

In another evaluation of general Internet site quality, Sowards (1997) emphasizes that Internet sites should center around users' potential needs: "Flawed thinking about users' needs will undercut purpose, confuse execution, and ultimately interfere with use." Sowards focuses on the ease with which users can find what they are looking via efficient layout, design, and content. This is attained through minimizing unnecessary design elements and content, having options available for internal navigation, and using a consistent set of visual elements.

Since medical Internet sites are held to a high standard of quality, several scholars in the medical field have conducted studies to assess their quality. Tweddle et al (1998) note that while numerous studies in medical publications stress issues of content and the subcategories of reliability, coverage, and attribution, other studies have focused on the screen design, structure, and functionality of Internet sites. They conclude that both should be given equal credence with a general emphasis on content, readability, evaluation, and design of the Internet site. Similarly, Winker et al. (2000) mention several deficiencies in the quality of medical and health information Internet sites including inequitable access to information, imbalance between user literacy and the information provided, and extreme variability in the quality of content.

Transit Sources

The evaluation of information dissemination via the Internet has also reached transit agencies. Peng et al (1999) used seven criteria to assess the suitability and usefulness of transit information media: accessibility, versatility, interactivity, information carrying capacity, user friendliness, cost to install, cost to use and ease of implementation. They argue that transit Internet sites possess a number of unique qualities that other information mediums lack, including the capability to combine various information sources while maintaining user interactivity. The importance of interactivity is underscored by an evaluation of New York City's Metropolitan Transit Authority (MTA) telephone information service, where Colletter et al. (1993) conclude that interactivity appears to be an important attribute of transportation information systems.

Recent studies (e.g., Schaller, 2002; Kenyon et al, 2000; Volpe National Transportation System Center, 2002) have examined transit agency Internet sites from the perspective of the site developer. The Volpe Center (2002) examined attributes of sites to develop usability ratings. These attributes focused on content (including trip planning), transit route information, tourist information, links, and contact information. Similarly, Young (2002) studied the MTA Internet site that provides transit information for several New York City transit agencies (New York City Transit, Long Island Rail Road, Long Island Bus, and Metro-North Railroad) to determine the types of information that are important to transit users and therefore important for transit agencies. Young (2002) found that the most frequently visited pages on the MTA site were the map pages with schedule and fare information pages coming in second. This finding supports Schaller (2002), who emphasizes the importance of map, schedule, and fare information since they are the most basic and frequently used resources of any transit Internet site. Schaller (2002) also suggests that transit agencies develop trip planners and highlights the importance of designing for the different audiences that will visit the agency's site. With respect to design, Schaller (2002) stresses that the design of the Internet site should be as easy to use as possible, mainly by allowing visitors to find relevant information quickly and simply. Kenyon et al. (2002) underscore these suggestions by indicating that transit Internet sites should be easy to use, support the user, and allow for user feedback.

In summary, the literature on Internet site evaluation suggests practical criteria that can be used to assess the usefulness of current sites. Classified broadly, these can be grouped into four areas: design (Smith, 1997; Sowards, 1997; ,Schaller, 2002; and Kenyon et al, 2002), content (Grassian, 2000; Smith, 1997; Sowards, 1997; and Winker et al, 2000, Volpe National Transportation System Center, 2002), functionality (Tweddle et al, 1998; Volpe National Transportation System Center, 2002), and accessibility (Tweddle et al, 1998, Winker et al, 2000; Peng et al, 1999). Design includes features such as ease of navigation and consistency of presentation. Content includes attributes such as availability of system-level, route-level, or zonal maps; schedule and fare information; and coverage and currency of the information provided. Site functionality involves the possibility of planning a trip, degree of interactivity, and the possibility of readily providing feedback or contacting an agency employee or contractor. Finally, accessibility includes readability, size of font, and the appropriateness of information provided for different types of users. These criteria were included in the rating instrument described in the following section.

3.3 Developing the Internet Site Evaluation Tool

Considering practical and theoretical aspects for evaluating transit information, the rating instrument was designed. Responses to each question were nominal (yes/no) and ordinal (based on a seven-point Likert-like scale with a score of seven corresponding to the best rating an Internet site could attain). The agencies sampled were rated by one of two evaluators. Because of potential biases inherent in each evaluator’s ratings, we tested for rating bias and uniformity. Table 1 presents the questions in the rating instrument classified based on evaluation criteria.

Table 1 Questions in Rating Instrument, classified based on Evaluation Criteria

	Theoretical Aspects	
Practical Aspects	Search Costs	Cognitive Costs
Design	- Is the site easy to navigate?	- Is the site easy to navigate? - Is information in a format that does not assume prior knowledge about the particular transit system?
Contents	- Does the site have a system or route map? - Does the site have a schedule available? - Does the site have fare information?	- Is a map easy to use? - Is a schedule easy to use?
Functionality	- Does the search function exist? - Does the front page contain contact information? - Is there a comment form where feedback is needed? - Does the site have links to other related sites?	- Is a trip planning function easy to use? - Does the site have a trip planning function?
Accessibility		- Is the font size, style, color and contrast with the background appropriate for reading?

All the questions for reducing search costs except one regarding the ease of navigation are nominal (yes/no) questions. As noted previously, search costs are the costs of gathering information. Accordingly, search costs are more related to the existence of information; if the information is available, it can potentially reduce search costs. Therefore, questions with respect to search costs are mainly about whether certain types of information exist in the Internet site.

On the other hand, since cognitive costs are the costs of making a decision given a set of information, most questions regarding reducing cognitive costs are relevant to measuring the quality of information; if the quality of the information is high, cognitive costs are reduced. Thus, these questions are mainly answered on a Likert scale with 1 as the lowest and 7 as the highest quality except the question that addresses the existence of search function.

Some of the criteria need to be explained further. The purpose of the question, ‘is information in a format that does not assume prior knowledge about the particular transit system?’ is based on Hsee’s (1996) idea to see if the visual display of information help lower cognitive costs. This is particularly important to accommodate infrequent users and tourists. If transit information is presented without any visual aides or further detailed explanations about the transit system, information may not be highly usable for infrequent users and tourists. By considering infrequent users in the information format, complex information can be laid out in a user-friendly way. This question is critical for large agencies desiring to display large amounts of information. For example, Figure 1 presents the interactive map for the Metropolitan Transportation Authority Long Island Railroad in the New York area.

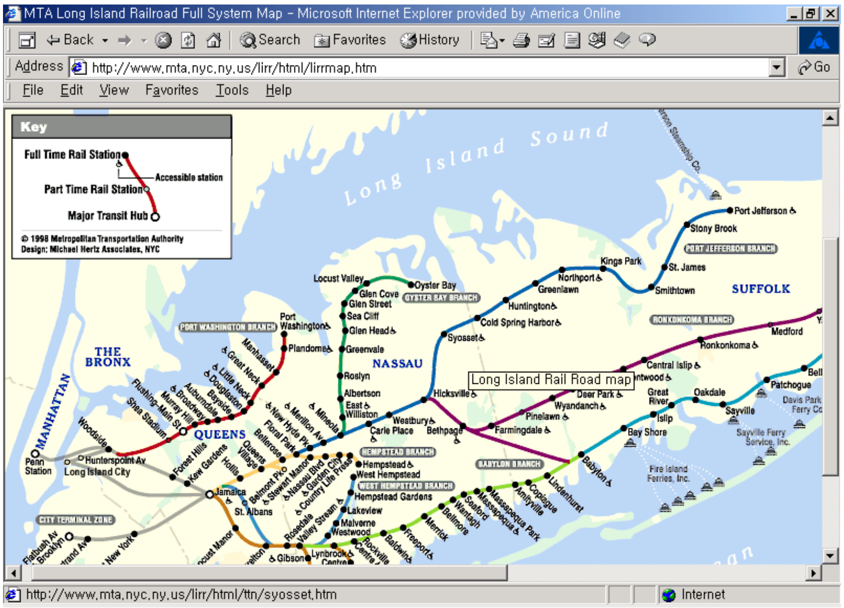

Figure 1 Long Island Railroad Interactive Map and Schedule

Using this map, potential transit users can see the geography of the service area first, then select a destination. If transit users select any particular route, they can obtain information regarding the selected route such as a schedule of the specific route. By presenting a map visually, infrequent users or tourists can relatively easily acquire the particular information they want.

Figure 2 also shows route map page in the Miami Valley RTA (Regional Transit Authority) Internet site. In this site, the transit agency presents map links by indicating destinations located along the specific routes. This way of presenting information may be useful for regular transit riders. However, if transit users are not familiar with the service area, it may be difficult for those users to select appropriate links and acquire the information they want. They may have to check every link to locate their destinations and relevant information.

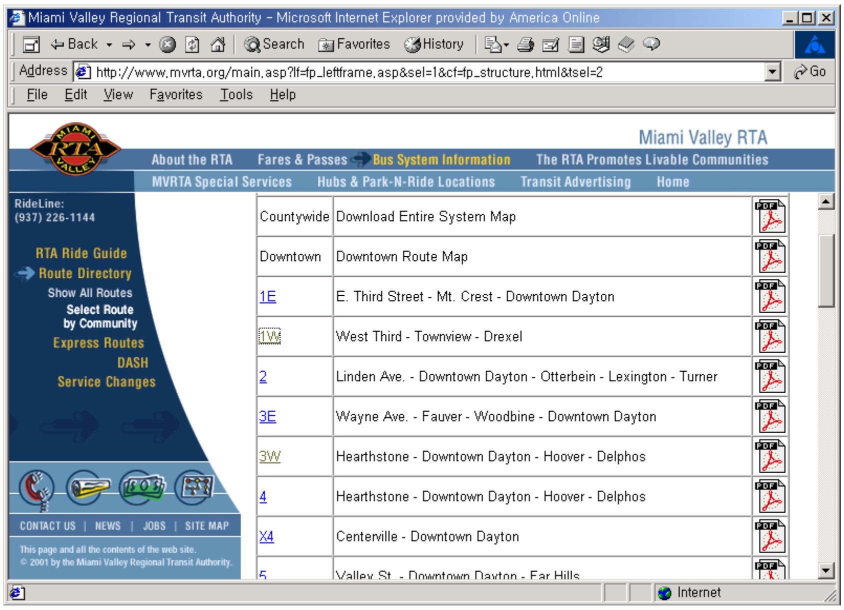

Figure 2 Miami Valley RTA (Regional Transit Authority) Route Map

The question 'is the site easy to navigate?' also involves the design of the site based on Hsee's idea (Hsee, 1996). For example, if the Internet site is very large and users need to scroll down to see all the information, a fixed navigational aide on one side of the screen would help the user to navigate through the Internet site and find relevant information. Figure 3 and Figure 4 show a navigational aide on the Central Ohio Transit Authority (COTA) Internet site. The navigational aide on the left in Figure 3 does not move when different information is presented in Figure 4.

Figure 3 Navigational Aide in Central Ohio Transit Authority (COTA) 1

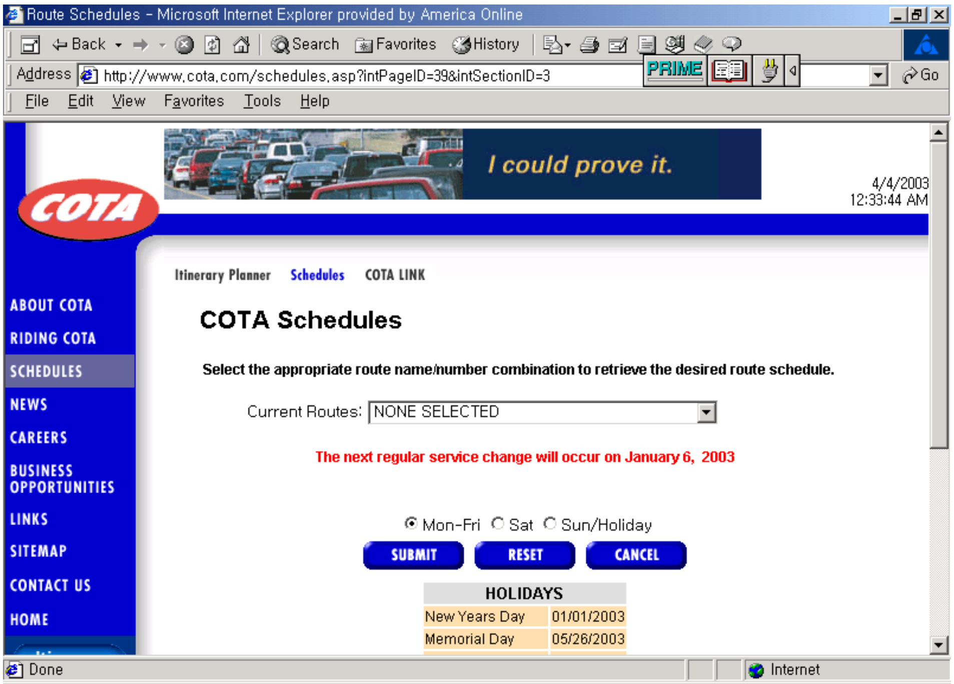

Figure 4 Navigational Aide in Central Ohio Transit Authority (COTA) 2

The question ‘is a trip planning function easy to use?’ is also related to how to accommodate infrequent users and tourists. For example, in some cases the user needs to input the exact address of the origin and destination to use a trip planner. If the user is not familiar with the particular area, these trip planners may not be useful. More advanced trip planners would give the user several itineraries, if the user only inputs the name of any landmarks or intersections near the origin and destination. These types of trip planners would be highly useful for infrequent users and tourists, and the quality of these trip planners would be highly rated. Another characteristic of a highly rated trip planner is that the itinerary which a trip planner produces is presented as a simple route map. In this way, it may be easy for the user to understand where they are traveling.

4. Data Collection

Data for this study are sampled from the 586 transit agencies listed in the National Transit Database (NTD) for the year 2000. Since this study utilizes the NTD data as reported by each transit agency, 68 agencies were discarded because they did not report adequate data in the year 2000.

4.1 Sampling Scheme and Data Summary

In order to be able to draw inferences for agencies of large, medium and small sizes, the remaining 518 agencies were categorized into strata based on the agency’s ridership (annual unlinked passenger trips) defined as large systems with 50 million or more trips, medium systems with between 5 million and 50 million trips, and small systems with 5 million or less trips. As a result, 33 agencies were classified as large, 91 as medium, and 394 agencies were classified as small.

To determine the sample size for each stratum, the acceptable margin of error was determined to be 10 percent, the standard deviation was maximized at 0.5, and the z-statistic was set at 0.05 significance level. Resulting sample sizes are 24 large agencies, 46 medium agencies, and 77 small agencies, for a total of 147 agencies. The process of sampling for each stratum is presented in Figure 5.

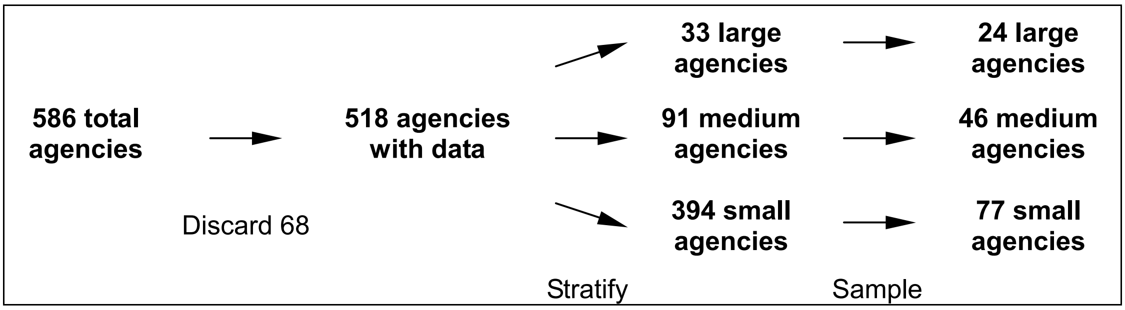

Figure 5 Transit Agencies Sampled by Ridership

Agencies are stratified and sampled based on operating budget and the sampling yielded in similar results (see Appendix 2 for detail). Table 2 shows the descriptive statistics for all strata of the data sampled based on ridership. Relatively high standard deviations are shown for the operating budget and ridership. Also, we can see that averages for both operating budget and ridership are slightly less than the threshold value used for classifying large agencies.

Table 2 Descriptive Statistics for Data Sampled

Service Attributes of Transit Agencies	Average	Standard Deviation	Maximum	Minimum
Annual Ridership (million)	46.11	215.71	2,500.00	0.02
Annual Operating Budget (million)	97.46	328.50	3,500.00	0.04
Annual Vehicle Miles (million)	9.98	18.32	120.00	0.04

4.2 Reliability of Ratings

Two evaluators each evaluated half of the number of Internet sites sampled for each stratum. Of course, ratings are expected to differ across evaluators, since some random differences are expected and more importantly because many factors play into judging the quality of an Internet site, even along a narrow category, such as map quality. Because the evaluations are subject to potential bias from the evaluator, each evaluator was also asked to rate 13 Internet sites that the other evaluator had rated, with a total of 26 sites rated by both evaluators. The sites jointly rated can thus be tested for rating bias and uniformity.

A common way to measure rater agreement is to use the Kappa statistic. However, use of such a measure has become increasingly controversial in part because using a kappa statistic to quantify the actual level of agreement assumes the statistical independence of raters, which is rarely the case. Thus, the kappa measure may be low even though there are high levels of agreement when individual ratings are accurate (see generally Uebersax, 1987). As a result, we used a Pearson correlation calculated among common ratings to assess the degree of association between the two evaluators. To assess rater bias, we performed a paired t-test between each pair of ratings for all criteria, resulting in eight correlation coefficients. Finally, we estimated a regression of the common ratings of the first evaluator against the ratings of the second evaluator. An ordinary least squares (OLS) regression was used for ratings measured using the Likert criteria, whereas a logistic regression was used for ratings involving binary (yes/no) outcomes. A significant coefficient for the second evaluator would indicate bias and would prompt us for remedial action.

Pearson correlation coefficients estimated for each criterion (ranging from 0.392

to 0.825) suggest a high degree of association between both evaluators. The t-tests detected evaluator bias in five of the eight ordinal questions. Accordingly, the OLS results suggest significantly different scores for criteria related to map quality (t-statistic = 4.033, $P < 0.01$), schedule quality (t-statistic = 3.079, $P < 0.01$), trip planner quality (t-statistic = 7.14, $P < 0.01$), amount of prior knowledge needed to use the site (t-statistic = 2.141, $P < 0.05$), and first impression (t-statistic = 2.085, $P < 0.05$). The ratings of the second evaluator these for these five criteria ratings given by the second evaluator were adjusted using the coefficient and constant, if significant, estimated in the regression equation.

5. Evaluation Results

From the Internet site evaluation results, this study attempts to correlate virtual representations of transit agencies with physical attributes of the transit agencies.

5.1 Evaluation of Virtual Presence

From Figure 6, the first bar shows the percentage of transit agencies that developed Internet sites. One hundred and five sampled agencies among 147 (71%) agencies have Internet sites. Among these 105 Internet sites, most Internet sites contain maps, schedules, and fare information (85%, 98%, and 90% respectively). 69% of Internet sites have links, and a half of Internet sites include search functions and contact information on front pages. Only 23% of Internet sites maintain trip planner and 23% of Internet sites are designed to send feedback to transit agencies by users.

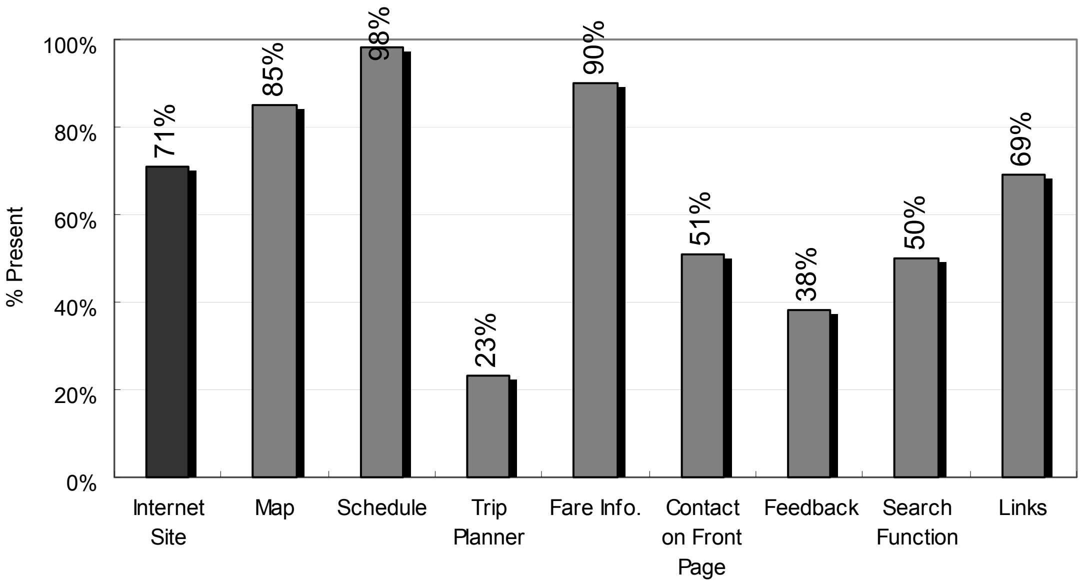

Figure 6 Presence of Internet Site Features

In Figure 7, average scores of ratings from Internet site evaluations are summarized. For map, schedule and trip planner quality, transit agencies without those information are excluded.

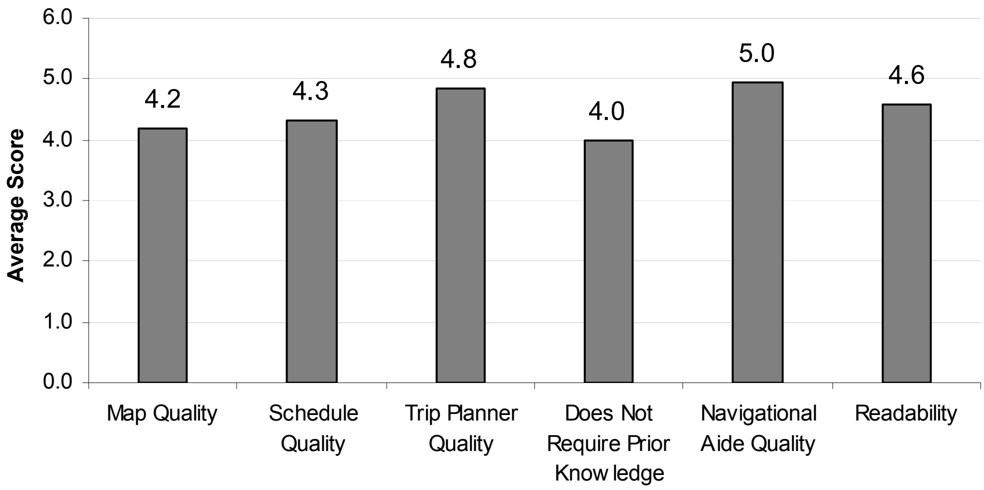

Figure 7 Summary of Internet Site Ratings

5.2 Association between Transit Agency's Virtual Locale and Physical Attributes

To correlate the transit agency's virtual locale and its physical attributes, we conducts both qualitative and quantitative analysis. For the qualitative analysis, transit agencies are divided into large, medium and small strata based on ridership. Operating budget is also used to classify agencies for the analyses. However, the analysis results are similar with agencies that are classified based on ridership. The results are presented in Appendix 2. For the quantitative analysis, two stage sample selection modeling and regression modeling are performed.

5.2.1 Size of Transit Agency and Presence of Internet Site

Figure 8 indicates the percentage of transit Internet site availability by agency sizes.

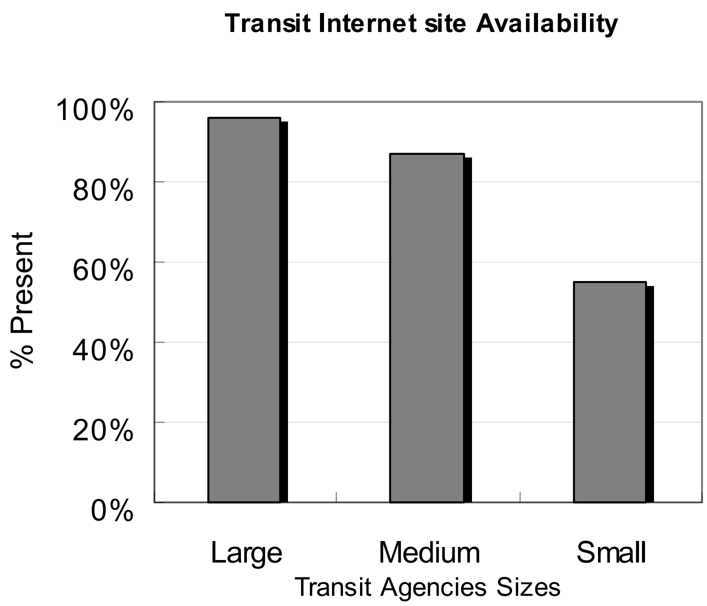

Figure 8 Internet Sites Existence (%)

From Figure 8, of the 24 large agencies evaluated, 23 (96%) have Internet sites, while one agency does not have a site. Fourty of 46 medium agencies (87%) have Internet sites, but six agencies (13%) do not have an Internet site. Of the 77 small agencies, 42 agencies (55%) have Internet sites but 35 agencies (45 %) do not have Internet sites. Therefore, the 105 transit agencies with Internet sites out of 147 sampled transit agencies evaluated in this study were composed of 23 large, 40 medium, and 42 small agencies.

Figure 8 suggests a positive correlation between transit agency size and the existence of Internet site. Generally, large and medium transit agencies tend to provide transit information through Internet sites, while almost half of small transit agencies do not use Internet sites for disseminating transit information. One of the reasons for this observation is that it is likely that large transit agencies with a large ridership need to reach a great number of riders and large transit agencies may need to outreach beyond their jurisdictional boundaries for serving tourists. Therefore, using only traditional ways of disseminating transit information to reach their potential transit riders may not be appropriate and Internet sites can provide more efficient medium in this sense. Small transit agencies may not feel a great need for outreach customers beyond a relatively small number of regular transit riders, therefore small agencies may not choose to use Internet sites to reach transit riders.

5.2.2 Size of Transit Agency and the Presence of Internet Site Features

Through the evaluation of the Internet sites of transit agencies, we attempted to see if there is a correlation between the size of transit agency and the presence of features in their Internet sites. Figure 9 indicates the presence of features in Internet sites for large, medium and small agencies.

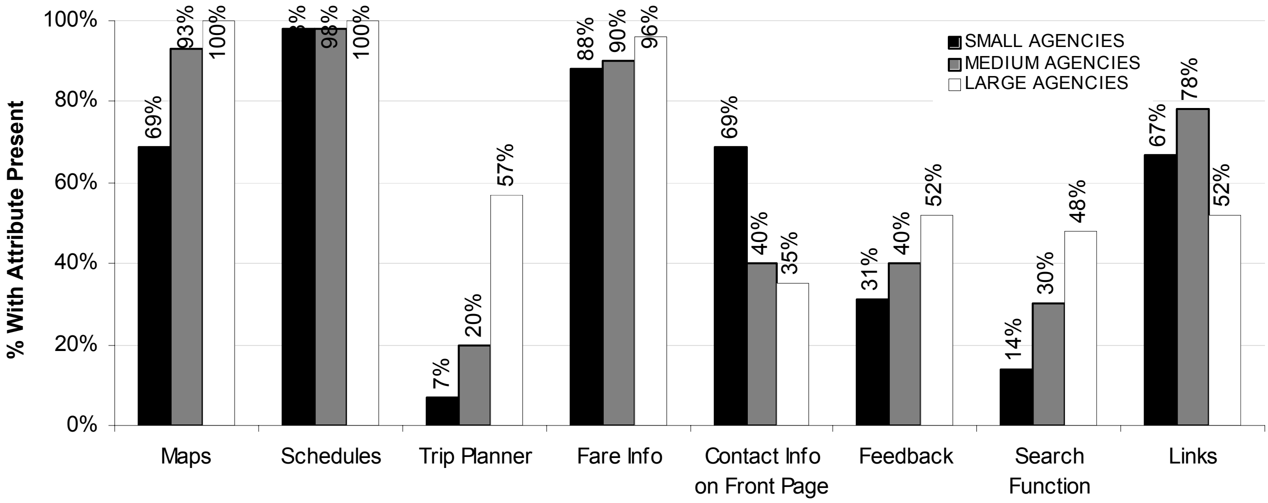

Figure 9 Internet Site with Selected Attributes for agencies with Internet Sites, Stratified by Ridership

While most sites contained maps, schedules, and fare information for their routes, about 30% of small transit agencies do not provide route or system maps. This finding is self-evident in that these features are most commonly used types of transit information by both frequent and infrequent transit users. Accordingly transit agencies tend to provide the important information through Internet sites. Also, the percentages of the presence of maps, schedules, trip planners, and fare information increase as ridership increases. For the same reason, this also comes as no surprise, since the usefulness of these pieces of information would be increase as system size increases.

As evident in Figure 9, 7% of small agencies, 20% of medium agencies and 57% of large agencies have trip planners in their Internet sites. In Smith (2002)'s study of trip planner, the author indicated the limitations of traditional approaches such as a printed brochure and telephone service in providing route and schedule information compared to an online trip planners. Regarding a printed brochure, transit users are required to complete complicated analysis to obtain an itinerary from the brochure that meets their needs. Additionally, it may not be effective for the operator of telephone service to describe the system verbally, if the transit user is unfamiliar with the region.

The author suggested that trip planners using Geographic Information System (GIS) and the Internet can help to overcome these limitations. Furthermore, since difficulties for transit users are more prevalent when users are infrequent transit riders or tourists, trip planners may help transit agencies accommodate various user groups.

The larger the agencies are, the more the trip planners are available. Logically, when a transit system is larger and more complicated, trip planners would be more useful for infrequent transit users as well as regular transit users. This line of reasoning suggests that small and medium agencies may not feel a great need for attracting tourists and retaining infrequent transit users, perhaps because their systems are less likely to serve tourists. On the other hand, since large transit agencies tend to serve a number of tourists and infrequent users, these agencies may feel that they should spend as many resources to make their systems convenient for tourists and infrequent users as well as regular transit riders.

Another finding indicates that Internet sites of small agencies are most likely to have contact information on their front pages and the percentage for this likelihood decreases as agency sizes increases. This may due to less feasibility of providing personalized attention to patrons in larger transit agencies. Small and medium transit agencies may be better able to provide more one-on-one attention to transit users via email or telephone due to their relatively small sizes of their systems when compared to larger transit agencies. This may also help to explain why large transit agencies are most likely to have a search function; they want users to find the information they need on their Internet sites without personalized assistance. The facilitation of search functions also makes sense for large agencies since they are more likely to contain a large amount of information in their Internet sites.

On the contrary, medium and small agencies may not feel a need to provide a large amount of information because of lower demands for transit service. Instead, they tend to provide unavailable information using links to other related Internet sites. Indeed, we can see in Figure 6 that small and medium agencies are more likely to provide links to other related Internet sites than large agencies.

With regard to the provision for feedback, large transit Internet sites are more likely to have feedback forms because the more riders an agency has, the more transit users may want to give feedback. Thus, they may need to take these users' feedback into account. However, it should be noted that only slightly more than half of large transit Internet sites provide feedback forms.

5.2.3 Size of Transit Agency and the Quality of Transit Information

Table 3 provides the result of the evaluation of transit information quality.

Table 3 Descriptive Statistics for Evaluation Scores (Strata by Annual Ridership)

	Large Agencies				Medium Agencies				Small Agencies			
Criteria	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Map	**3.94**	1.09	1.56	6.00	**4.48**	1.33	2.33	7.00	**4.07**	1.51	1.56	7.00
Schedule	**4.16**	0.10	2.00	6.00	**4.59**	0.70	3.00	6.00	**4.31**	0.86	3.00	6.00
Trip Planner	**4.30**	1.58	2.89	6.00	**4.97**	0.74	4.00	6.00	**4.95**	1.51	2.17	7.00
Prior Knowledge	**3.61**	1.14	1.00	7.00	**4.23**	1.17	2.00	6.00	**4.37**	0.91	2.94	6.00
Navigation Aide	**4.48**	1.55	1.00	6.00	**5.25**	0.82	3.00	7.00	**5.22**	0.85	3.00	6.00
Readability	**4.52**	0.89	2.00	6.00	**4.58**	0.93	3.00	6.00	**4.70**	1.06	2.00	6.00

We found that the average score for most attributes was similar between medium and large transit Internet sites but less so for small transit Internet sites. T-tests indicate that there is a significant difference ($P < 0.01$) between the average scores of small and medium agencies and between small and large agencies. However, a significant difference does not exist between medium and large agencies. Accordingly, small transit agency Internet sites generally scored lower than medium and large transit Internet sites and large transit Internet sites did not always score higher than medium-sized agencies' Internet sites. Figure 11 shows a graphic presentation of Table 4.

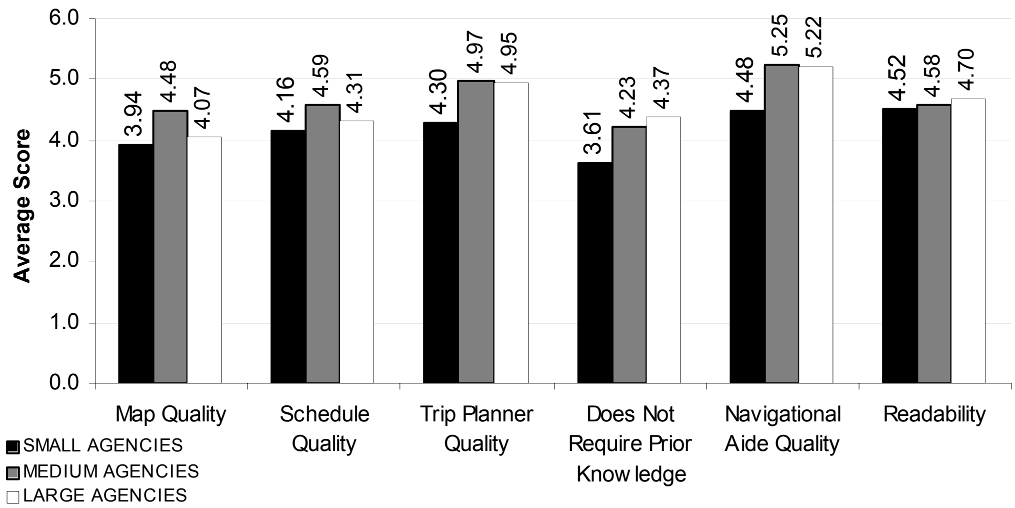

Figure 10 Average Scores for Internet Sites by strata (Ridership)

As evident in Figure 10, of map, schedule, and navigational aide quality for the Internet sites of medium-size agencies appear to receive the highest scores. This is perhaps due to diseconomies of scale kicking in after a certain size, although the difference between large and medium agencies is not statistically significant. For instance, a schedule and route map for a small transit system may not have to be of a high good quality, since a small system may be simple and easy enough for users to extract the itinerary from any quality of maps and schedules. The quality of map and schedule may increase as the size of transit system increases.

However, a large transit system is likely to be more complicated, thus, maps and schedules may not be easily presented through the Internet site unless the site has special features such as a zoom-in or zoom-out function. For the quality of trip planners, the average score for small agencies is noticeably lower than for medium and large agencies. As previously noted, this maybe because the larger the agency, the more the agency makes an effort to accommodate infrequent users and tourists as well as regular transit riders.

By size, the trend of average score for navigational aide is similar to the quality of the trip planner. High quality navigational aides may not be necessary for small Internet sites; since Internet sites of small agencies are not likely to contain a large amount of information and small agency's Internet site may have a simple structure, it can be easy enough for users to find the information they need without a good navigational aide.

It appears that the larger the Internet sites, the higher, the readability and the less prior knowledge is needed to use the Internet site. This can be interpreted as a sign that larger transit agencies have attempted to make Internet sites user-friendly, since the number of transit users is large and because various groups of riders use the Internet sites as the size of agencies becomes larger.

In summary, we find some appreciable differences in the quality of Internet sites across agencies, what appear to be related to the agency's size based on ridership. That the results are supportive of the hypothesis of diseconomies of scale is an important finding of this analysis. In the next section we attempt to associate the quality of the transit agency's site with standard service performance information such as operating budget, vehicle miles, and unlinked passenger trips through quantitative analysis. Such data may help explain the reasons behind some of the differences between agencies.

5.3 Statistical Modeling

To draw quantitative association between transit agencies' physical attributes and transit information, regression models are estimated using the sampled data. The statistical model may point toward more specific relationships between key transit service attributes and the information on their Internet sites.

5.3.1 Modeling Structure

For statistical modeling, the data are weighed appropriately to correct for the over-sampling of large and medium-sized agencies. Then, statistical models are developed with the presence of certain types of information or ratings as dependent variables and agency service performance indicators as explanatory variables. Although causal relationship between service attributes and the quality of an Internet site cannot be established with this analysis, potential associations can be investigated. Thus, this analysis is limited to exploring reduced-form associations that can assist us in explaining the presence and quality of Internet sites.

For the analysis, this paper estimated ordinary least squares (OLS) regression models on the ordinal ratings data and probit regression models with the dependent variables as the presence or absence of key Internet site attributes. However, because the presence of each attribute and the ratings are recorded only when an agency had an Internet site or an Internet site contained the information, the estimation of such models may not be made directly; otherwise, the coefficients estimated can be biased (Heckman, 1976). This would occur when, for example, the factors that determine whether or not an agency has an Internet site also determine the quality of an Internet site when one exists. It stands to reason that many such factors exist.

Therefore, we also estimate OLS regression model with a sample selection equation where in the first stage the factors that influence whether or not an agency had an Internet site were examined. Only when an agency had an Internet site could we observe the quality of the site. Sample selection models provided a convenient mechanism to perform this analysis (Greene, 1993 and Heckman, 1976). In sample selection models, the probabilities of having an Internet site (yes/no outcome) are estimated using a binary probit/logit estimation routine, and are carried over into the next stage where an OLS model or a second limited dependent variable model is estimated on the quality of site or the presence of the attributes. The structure of this sample selection model is based on two regression equations:

$z^* = \alpha' v + u$ (binary probit/logit)

$y = \beta' x + \in$ (ordinary least squares or binary probit/logit, depending on the characteristics of the outcome of interest, y.)

where z^* and y are the dependent variables measuring if the subject accessed the information (yes/no) and the outcomes of interest to this study, respectively; **v** is a vector of independent variables; **x** is a vector of independent variables; α' and β' are vectors of estimated parameters and u and $\in$ are the error terms. Also, it is assumed that u and $\in$ have a correlation ρ. When $\rho \neq 0$, standard regression techniques that are applied to the second equation yield biased results. ρ should be constrained within its valid limit (-1, 1). Another necessary condition for model identification is that the variables **v** should not match exactly those in **x.** This allows us to simultaneously examine the relationship between service performance indicators and whether or not an agency had an Internet site, and if so, their relationship with the quality of the site.

Five OLS models and OLS-selectivity equations were estimated for the quality of maps, schedules, readability, navigational aides and how much prior knowledge is required. Similarly, ordered probit models with and without sample selection equations are also estimated for those information as dependent variables. Ratings from 1 to 7 are categorized as 0:1,2; 1:3,4; 2:5,6,7. Since the overall results of those models are not more significant than OLS models, the results are presented in Appendix 3.

This paper estimated three probit models and probit-selectivity models for the presence of contact information on the front page, feedback function, and links to other Internet sites. The ratings for the presence of trip planning functions and search functions were excluded from this analysis, because they occurred rather infrequently. The presence of fare information was also excluded, because, as observed in the previous sections, almost 90 percent of agencies have fare information regardless of strata.

5.3.2 Variables Used in Models

Annual operating budget, ridership, and vehicle miles are used as indicators of transit service performance. Squared-vehicle miles and squared-ridership are also used as explanatory variables. The rationale for using squared-terms is that diseconomies of scale in the quality of information after a certain agency size were hypothesized and detected to some extent in the previous sections (the quality of maps, schedules, trip planners, and navigational aides are classified based on ridership). Those squared-terms would test the hypothesis of potential diseconomies of scale in the provision of information, depending upon those transit service characteristics. Operating budget per trip is also used as one of the explanatory variables to control the effect of transit agency size on the quality or availability of the information.

5.3.3 Modeling Results

Sampled data of 147 transit agencies are used for the OLS and probit models with sample selection equations. For models without sample selection equations, uncensored data from previous two stage models are used. No significant effects are detected regarding readability and the presence of contact information on the front page. Table 4, 5,and 6 show the results of the models. Overall, the coefficients in OLS or probit models with and without sample selection equations show identical directions and similar magnitudes. This may mean that the quality or presence of information is not highly biased according to whether or not a transit agency has an Internet site. ρ, indicating correlation between selection models, was insignificant in all the models. Also, R^2 and Pseudo R^2 for OLS and probit models without sample selection equations show relatively poor fit, indicating that the models explain less than 1% or 2% of the variances in the quality or probability of information presence.

Table 4 OLS and Sample Selection Models for Map and Schedule Quality

	MAP			SCHEDULE
	Sample Selection Model		OLS Model	OLS Model
	Map Quality Coefficient (z-statistic)	**Presence of Map** Coefficient (z-statistic)	**Map Quality** Coefficient (t-statistic)	**Schedule Quality** Coefficient (z-statistic)
Constant	4.503*** (18.22)	-0.445*** (-2.81)	4.364*** (24.72)	4.568*** (26.42)
Vehicle Miles (1 million)		-1.512* (-1.74)		1.142 (0.28)
Operating Budget (1 million)		0.761 (1.21)		
Ridership (1 million)	-0.026 (-0.83)	11.090*** (3.42)	-0.031 (-0.86)	
Budget / Ridership	-0.053*** (-2.79)		-0.054*** (-2.80)	-0.075*** (3.24)
Squared Vehicle Miles (1 million)	-1.337** (-2.43)		-1.102* (-1.88)	
Squared Ridership (1 million)				-0.003*** (-2.90)
N (Uncensored N)	147 (89)		89	
ρ	-0.162			
σ	1.193			
λ	-0.193			
Wald Chi^2 test	42.71***			
R^2			0.055	0.093
Mean VIF			2.470	1.260
Root MSE			1.214	0.956
F statistic			8.46***	53.40***

Wald Chi-square statistic tests all coefficients in the regression model being 0.
*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level

From Table 4, while initially OLS-selectivity models for map and schedule quality were performed, OLS model with sample selection equation for schedule quality shows that ρ is 0, meaning that the results of the OLS model are not biased by the sample selection equation. Thus, only the OLS model for schedule quality is presented in Table 4. The OLS model with sample selection equation for schedule quality is presented in Appendix 3. For map quality, two OLS models with and without sample selection show similar coefficients and ρ is also not statistically significant. The estimated coefficients of the OLS-selectivity model for map quality show that map quality decreases as squared-vehicle miles increase and schedule quality also decreases as squared-ridership increase. This supports the hypothesis regarding potential diseconomies of scale in the provision of that information. Accordingly, the complexities of managing large amounts of information for large agencies may mean that, as currently used, certain benefits of information organization and dissemination with the Internet remain to be tapped by these agencies.

Another finding indicates that operating budget per trip is highly significant in both models and coefficients show negative effects on map and schedule quality, meaning that transit agencies with a high operating budget per trip are less likely to have good quality of maps and schedules. This finding may support the diseconomies of scale in presenting information to some extent that it is difficult for large agencies to lay out map and schedule information in a usable and processable format. Ridership in the map quality model also shows negative signs, but is not statistically different from zero and the variable. Vehicle miles in the schedule quality model also bears a positive sign, but is not statistically significant.

In the sample selection equation for the map quality model, vehicle miles, ridership, and operating budget are used as explanatory variables. The dependent variable in this equation takes into account whether a transit agency has an Internet site, and if an agency has an Internet site, whether or not the site contains maps. Vehicle miles have negative effect on the presence of maps, while ridership has positive effects on the presence of maps. This result may indicate that ridership is a positive factor for transit agencies in deciding to include maps. Operating budget also shows a positive sign, but is not statistically different from zero.

Table 5 shows the relationship between service characteristics and whether prior knowledge is required or the quality of navigational aides. Although sample selection model is used for the prior knowledge requirement, the result indicates that ρ = 0, indicating that the model results are not biased by sample selection equation. Therefore, only the OLS model is presented, and Appendix 3 contains the sample selection model for this variable.

Table 5. OLS and Sample Selection Models for Prior Knowledge Requirement and Navigate Aide

	PRIOR KNOWLEDGE	**NAVIGATIONAL AIDE**		
	OLS Model	**Sample Selection Model**		**OLS Model**
	Prior Knowledge	**Nav. Aide**	**Presence of Site**	**Nav. Aide**
	Coefficient (t-statistic)	Coefficient (z-statistic)	Coefficient (z-statistic)	Coefficient (t-statistic)
Constant	3.542***	5.034***	-0.170	5.048***
	(15.06)	(17.60)	(-0.47)	(17.46)
Vehicle Miles	4.186**	5.153***	-52.085**	5.049**
(1 million)	(2.57)	(2.66)	(-1.96)	(2.56)
Operating Budget			256.851***	
(1 million)			(3.91)	
Ridership			-263.886***	
(1 million)			(-3.59)	
Budget / Ridership	0.016	-0.129***		-0.129***
	(0.59)	(-3.88)		(3.75)
Squared Vehicle	-3.702*	-5.408**		-5.305**
Miles (1 million)	(-1.89)	(-3.88)		(-2.34)
Squared Ridership		0.004*		0.004*
(1 million)		(1.85)		(1.80)
N (Uncensored N)	105	147 (105)		
ρ		0.193		
σ		1.309		
λ		0.253		
Wald Chi^2 test		68.21***		
R^2	0.055			0.178
Mean VIF	5.180			5.160
Root MSE	1.155			1.341
F statistic	3.22**			16.08***

Note that selection equations in the models for having Internet site or not show identical results.
*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level

Regarding the prior knowledge requirement, agencies with high vehicle miles are more likely not to require prior knowledge to use their Internet sites. This finding is consistent with findings from previous analyses when agencies are classified into large, medium and small strata based on ridership. However, squared-vehicle miles is significant and has a negative sign. This finding may also suggest that this trend is reversed due to diseconomies of scale beyond a certain size of agency. Operating budget per trip indicates a positive association, but it is not statistically significant.

With respect to the quality of navigational aides, coefficients in the OLS models with and without sample selections show the same direction with similar magnitudes. In this case, ρ is statistically insignificant, meaning that bias as a result of the sample selection equation is not significant. Vehicle miles shows a positive sign at 0.01 significance level, indicating that agencies with high vehicle miles are more likely to have good quality navigational aides. However, this trend is reversed again by the negative sign of squared-vehicle miles. While squared-ridership indicates positive sign opposite to squared-vehicle miles, its significance level is moderate. Table 7 gives the two probit model results for the provision of feedback and links.

Table 6. Probit Models for Provisions of Feedback and Links

	PROVISION OF FEEDBACK Probit Model	PROVISION OF LINKS Probit Model
	Feedback (yes/no) Coefficient (t-statistic)	**Link (yes/no)** Coefficient (t-statistic)
Constant	-0.464**	0.277
	(-2.20)	(1.18)
Vehicle Miles (1 million)		
Operating Budget	-0.336*	-0.242
(1 million)	(-1.74)	(-1.26)
Ridership	0.346	0.108
(1 million)	(1.61)	(0.43)
Budget / Ridership	0.054	0.066
	(1.56)	(1.44)
Squared Vehicle	1.663	4.700*
Miles (1 million)	(1.22)	(1.78)
Squared Ridership (1 million)		
N (Uncensored N)	105	105
Pseudo R^2	0.023	0.032
Wald Chi^2 test	4.860	5.22

Note that selection equations in the models for having Internet site or not show identical results.
*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level

In Table 6, since $\rho = 0$ in the probit models with sample selection equations for both the provision of feedback and links as dependent variables, they are presented in Appendix 3. Only the operating budget has a significant effect on the provision of feedback with a negative sign. This finding is different from previous findings regarding the provision of feedback. This analysis shows that large agencies with large operating budgets are less likely to provide feedback functions on their Internet sties. This result is inconsistent with previous findings that large agencies attempt to incorporate feedback from transit users.

Squared-vehicle miles is positively related to the provision of links at the 0.1 significance level. This result partly supports the previous findings that small agencies tend to direct users to other relevant sites when they do not have needed information.

Overall, the estimated models explain only small amount of variance in the quality or presence of information. Also, the results for the information quality and presence are not biased by whether or not a transit agency has an Internet site. Nonetheless, the statistical modeling confirms the diseconomies of scale detected from the previous analysis results. However, some findings are inconsistent with prior findings.

6. Conclusion

The purpose of this study is to identify the association between virtual representations and physical attributes of transit agencies. Based on economic theories of information search as well as practical aspects of Internet site evaluation, this study develops a rating instrument for evaluating Internet sites of transit agencies, identified using a stratified sampling technique that allows us to draw inferences for large, medium, and small agencies. Then, the association between the results of the evaluation and physical characteristics of transit agencies is investigated.

The evaluation results suggest that transit agency size, measured in terms of the number of yearly passengers, plays a key role in determining how transit information is disseminated to the user and the quality of such information dissemination efforts. The results indicate that beyond a certain agency size there appear to be diseconomies of scale in the quality of transit information disseminated via the Internet. In particular, medium-sized agencies' Internet sites received the highest scores in quality of maps, schedules, and trip planners; as the size of transit agency increases, the quality of information increases. However, after a certain agency size, the degree of complexity of a transit system may be too high, thus the information is not easily presented through Internet sites. Therefore, the quality of the information in large agencies is rated lower than medium agencies.

Large agencies received the highest scores in some of the design aspects of Internet site. Large agencies are more likely to be readable and require less prior knowledge than medium and small agencies, although diseconomies of scale are detected in the quality of other important transit information. This means that large agencies have made endeavors to make their sites more usable and processable for users. Perhaps it is critical for large agencies to provide a high quality of site design in order to sort out the large amount of information sought by the user, while presenting the information itself may be difficult.

Another finding indicates that large agencies are more likely to provide advanced information searching tools to reduce cognitive costs of users than medium and small agencies; large agencies are likely to provide trip planners and search functions. It can be interpreted that since Internet sites of large agencies contain a large amount of information, it may be difficult for users to locate particular information they want; thus, those agencies attempt to assist both regular and infrequent transit users in finding information by providing the advanced information searching tools.

On the other hand, medium and small agencies help transit users find information by offering person-to-person assistance or links to other sites containing relevant information. However, these strategies may be less feasible for large transit agencies, since those agencies are likely to maintain a large amount of information in their sites and accommodate a large number of transit riders; thus, it may be difficult for large agencies to provide one-on-one attentions to users.

To further explore the association between transit agency characteristics and Internet site quality, sample selectivity models are estimated. This rigorous methodological approach builds on the Internet site survey by examining systematic variations between agency characteristics and the Internet site ratings. The results of these models indicate that the models explain only 1 to 2% of the variance in the quality or presence of information and the results of the models for information quality and presence are not biased by the presence of Internet sites of transit agencies. However, the models confirm the diseconomies of scale in presenting information for large transit agencies.

That the results are supportive of the hypothesis of diseconomies of scale is an important finding of this research. Unfortunately, the current data are not appropriate to fully test this hypothesis, but findings are consistent with what the hypothesis indicates. Future research should apply more standard techniques to test for the presence of such potential diseconomies.

Appendix 1

Appendix 1 provides schools of thoughts regarding search costs and cognitive costs in relation to transit information.

Reducing Search Costs

Stigler (1961), who propounded the Economics of Information theory, suggested a framework for the information search behavior of consumers. The basic assumption of the framework is that all buyers do not have perfect information about the market. This implies that consumers perceive the costs of searching for information to be at different levels; thus, the expected benefits of search activity would guide consumers' search behavior for information (Stigler, 1961; Urbany, 1986). Search costs can be affected by the consumer's experience or knowledge of information and the uncertainty the consumer faces (Urbany, 1986).

The benefit from searching for information is positively related to the dispersion of different prices across a number of different sellers. According to Biswas (2002), a higher level of perceived price dispersion will lead to higher expected benefits from search activity. Alternatively, the expected benefit can also determine the total amount of searching undertaken by a consumer (Biswas, 2002). However, there are diminishing returns of benefits to continued searching; the expected benefits from search activity decrease as the activity continues (Goldman and Johansson, 1978). This implies that consumer incentives for search activity decrease after the activity reaches a certain level.

Price dispersion, mentioned above, is perceived as a necessary condition for consumers to undertake information search activities (Stigler, 1961). To prove this, a number of researchers (e.g., Stigler, 1961; Urbany, 1986) found a positive relationship between price dispersion and total amount of search. Another important variable that influences consumer search activity is search efficiency. Search efficiency is defined as the degree of a consumer's ability to identify the optimal search strategy (Biswas, 2002). Knowledge or experience about market conditions can enhance consumer's search efficiency. With high search efficiency, consumers can easily acquire and process new information.

Empirical studies found that the level of price dispersion in the Internet is greater than in a traditional market (Biswas, 2002). The Internet allows sellers to directly interact with buyers; therefore, sellers have the incentive to offer different prices based on consumer needs. By the same token, this may result in providing different versions of information about products. Also, a high level of customization is possible on the Internet; information can be provided to match the specific demand patterns of consumers.

Search efficiency is highly significant on the Internet, since there is an enormous amount of information on the Internet. Low start-up costs for sellers and the ability of consumers to overcome geographical constraints are likely to cause a high degree of information overload. This huge flow of information can overwhelm consumers in the search process. Biswas (2002) suggested that interactive decision aids and online search functions help consumers to enhance search efficiency.

Reducing Cognitive Costs

Regarding cognitive costs, Payne et al (1993) provided the implication of cognitive processes for decision-making. Their research is based on the idea that an individual uses multiple strategies in decision making in different situations; “it is an adaptive response of a limited-capacity information processor to the demands of complex decision tasks.” That is, decision makers decide how to solve problems using various strategies according to task environments. Simon (Newll and Simon, 1972 and Simon, 1990) provided a theoretical base on these thoughts that it is task environments that make decision processes complicated, since the information processing capabilities of the decision maker are limited.

Payne et al (1993) also noted that one of the primary considerations in decision-making is the desire to minimize the cognitive effort needed to reach a decision. Payne et al (1993) suggested that decisions can be improved by changing the way of displaying information. Russo (1977) furthered this argument by showing that making price information easy to process changed consumers’ actual purchase decisions. Similarly, Hsee (1996) proposed strategies for making information processable. Hsee’s idea focuses on the visual display of information to lower cognitive effort. The main idea is that if information is transformed and presented as an evaluative scale (good/bad), this can reduce the extra analytical efforts required for individuals in processing information. For instance, even if individuals understand some numbers at a basic level, they may not know what the numbers mean (e.g., how bad or good the number is).

Based upon Hsee’s idea (Hsee, 1996), research studies have been conducted to make health care information easy to process. Hibbard and Peters (2002) pointed out that the assumption that the provision of information can help informed decision-making is too simplistic [4]. Sometimes, non-usable information may create barriers to

[4] Marshall et al (2000) provided evidence of this argument.

consumers who are motivated to make a decision; consumers may feel frustrated and dissatisfied if the information provided is not processable. This is backed by Hibbard et al (2002) who indicated that if information is presented in a more evaluable format, people increase the weight of the information in their decision-marking process. Conversely, Hibbard and Peters (2000) demonstrated that consumers can be overwhelmed by the amount of information they receive about their Medicare choices and they may not understand the implication of their choices.

In the context of transit, transit systems consist of various sorts of information regarding geography, connections, and time. Thus, it may be a difficult cognitive process to integrate different types of information into the decision-making process (Payne et al, 1993). The statement of Hibbard and Peters (2000) fits well with transit context; “The challenge is not merely to communicate accurate information to consumers, but to understand how to present and target that information so that it is actually used in decision-making.”

Appendix 2

In Appendix 2, transit agencies are classified into large, medium and small agencies on the basis of operating budget. Based on this classification, the association between physical and virtual transit agencies are considered.

2.1 Sampling Scheme

Five hundred and eighteen agencies are stratified based on each agency's annual operating budget and are defined as follows; large systems have an annual operating budget of an $100 million or more; medium systems have an annual operating budget of between $20 million and $100 million; and small systems have an annual operating budget of $20 million or less. Accordingly, 35 agencies were classified as large, 86 as medium, and 397 as small. The acceptable margin of error (10%), the standard deviation (0.5), and the z-statistic set at the 0.05 significance level are used to determine sample sizes. The resulting sample sizes are 25 large agencies, 45 medium agencies, and 78 small agencies, for a total of 148 agencies. The process of sampling for each stratum is presented in Figure 2-1 below.

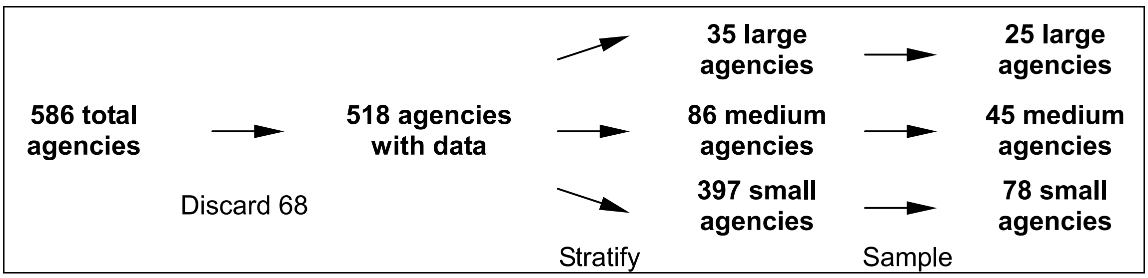

Figure 2-1 Transit Agencies Sampled by Operating Budget

2.2 Size of Transit Agency and Presence of Internet Site

Figure 2-2 shows the percentage of the existence of transit Internet sites by agency size stratified by operating budget. As is apparent in Figure2-2, all of the 25 large agencies evaluated have Internet sites. Fourty-four of the 45 medium agencies (98%) have Internet sites, while one agency does not have Internet site. Thirty-three of the 78 small agencies (42%) have Internet sites but 45 agencies (58 %) do not have Internet sites. Stratified by operating budget, the 102 transit agencies with Internet sites out of 148 sampled transit agencies evaluated were composed of 25 large, 44 medium, and 33 small agencies.

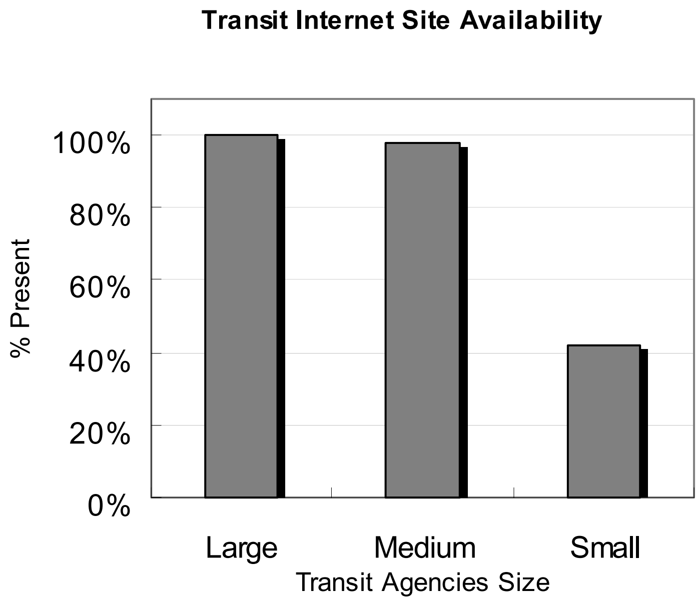

Figure 2-2 Internet Sites Availability (%),Stratified by Operating Budget

The positive correlation between the size of the transit agency and Internet site availability is clearer when agency sizes are divided by annual operating budget than by ridership. Both large and medium transit agencies are very likely to provide transit information through Internet sites, while more than half of small transit agencies do not disseminate transit information through Internet sites.

From these results, we can hypothesize that there is a non-linear relationship between the size of the agency and the presence of Internet sites; large and medium agencies above a certain level of budget tend to provide transit information through an Internet site, while agencies with less than a certain amount of budget will not have Internet sites, perhaps because small agencies do not have sufficient resources to develop and maintain Internet sites.

2.3 Size of Transit Agency and the Presence of Internet Site Features

Figure 2-3 shows the presence of features in Internet sites by agency size, stratified by operating budget.

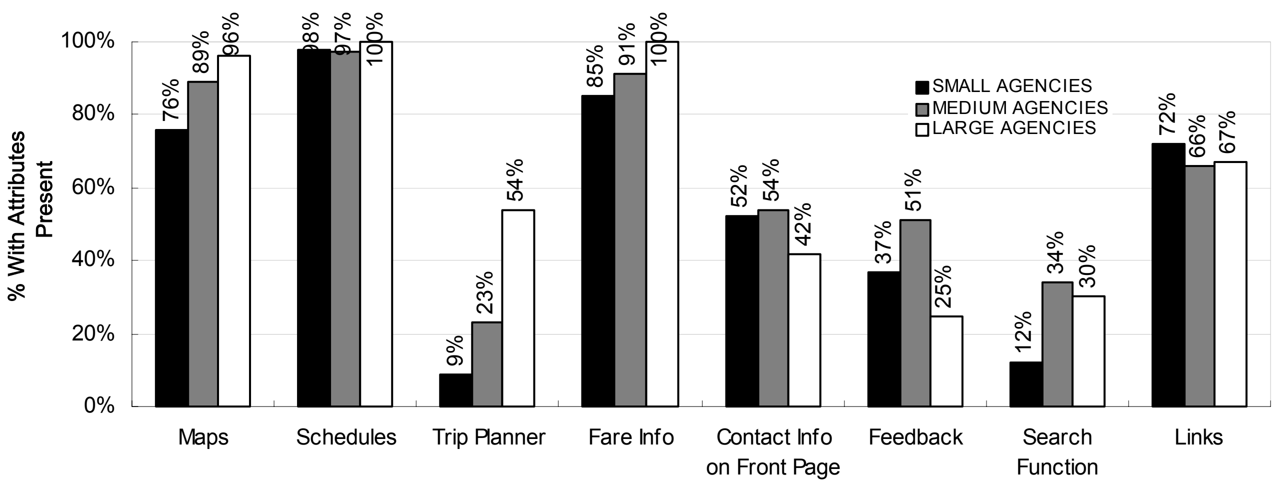

Figure 2-3 Internet Site with Selected Attributes for agencies with Internet Sites, Stratified by Budget

There are similar trends for the presence of maps, schedules, and fare information with transit agencies divided by ridership. Although about 25% of small agencies do not provide route or system maps, most agencies provide maps, schedules and fare information. Also, the percentages of agencies providing maps, trip planners and fare information increases as the size of the agency increases. This finding is consistent with agency sizes divided by ridership and also suggests that there is a positive relationship between providing information and the availability of resources in transit agencies.

With respect to trip planners, less than 10% of small transit agencies provide trip planners, as was the case when agencies were classified by ridership. However, the gap between medium and large agencies for providing trip planners is higher when agencies are classified based on ridership (57%-20%=37%) than when agencies are divided based on operating budget (54%-23%=31%). This finding may suggest that ridership is a more important factor for transit agencies when deciding whether or not to provide trip planners. In other words, the provision of trip planners may depend more upon the demand for transit rather than the financial resources of transit agencies.

Regarding the presence of contact information on the front page, feedback forms, and a search function, the percentages of providing these are highest in medium sized agencies. This observation may mean that medium sized agencies are more likely to respond to transit users and to provide personalized attention to transit riders when agencies are classified based on operating budget.

Large and medium agencies appeared to be more likely to provide a search function when compared to small agencies. Due to resource constraints, small agencies may not be able to provide a large amount of information, and may not need to because the small size of the system. Thus, small agencies may not need to provide a search function for users. We can also see that small agencies are more likely to provide links. As mentioned earlier, this may mean that they try to point users to other relevant sites when they do not have the proper information.

2.4 Size of Transit Agency and the Quality of Transit Information

Table 2-1 presents the average scores for transit information quality when agencies are divided based on operating budget.

Table 2-1 Descriptive Statistics for Evaluation Scores (Strata by Annual Operating Budget)

	Large Agencies				Medium Agencies				Small Agencies			
Criteria	**Mean**	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
Map	**4.14**	1.68	1.56	7.00	**4.33**	1.87	2.33	7.00	**4.11**	1.21	1.56	6.00
Schedule	**4.27**	0.84	0.84	6.00	**4.50**	0.23	3.50	6.00	**4.31**	1.03	2.00	6.00
Trip Planner	**4.49**	2.75	2.90	7.00	**5.12**	2.04	4.34	6.00	**4.95**	1.34	2.89	6.00
Prior Knowledge	**3.75**	0.90	2.94	6.00	**4.13**	1.19	2.00	6.00	**4.34**	1.20	1.00	7.00
Navigation Aide	**4.77**	1.30	4.00	6.00	**5.29**	0.96	3.00	7.00	**5.35**	1.59	1.00	6.00
Readability	**4.50**	1.02	2.00	6.00	**4.54**	0.95	3.00	6.00	**4.79**	0.89	2.00	6.00

Using t-tests, the average scores for most attributes are similar between medium and large transit Internet sites but less so for small transit Internet sites. T-tests indicate that there is a significant difference ($P < 0.05$) between the average scores of small and medium agencies and between small and large agencies. However, there is no significant difference between medium and large agencies. Accordingly, small transit agency Internet sites generally scored lower than medium and large transit Internet sites and large transit Internet sites did not always score higher than medium-transit Internet sites. Figure 4 presents the average scores for agencies' Internet sites classified by operating budget.

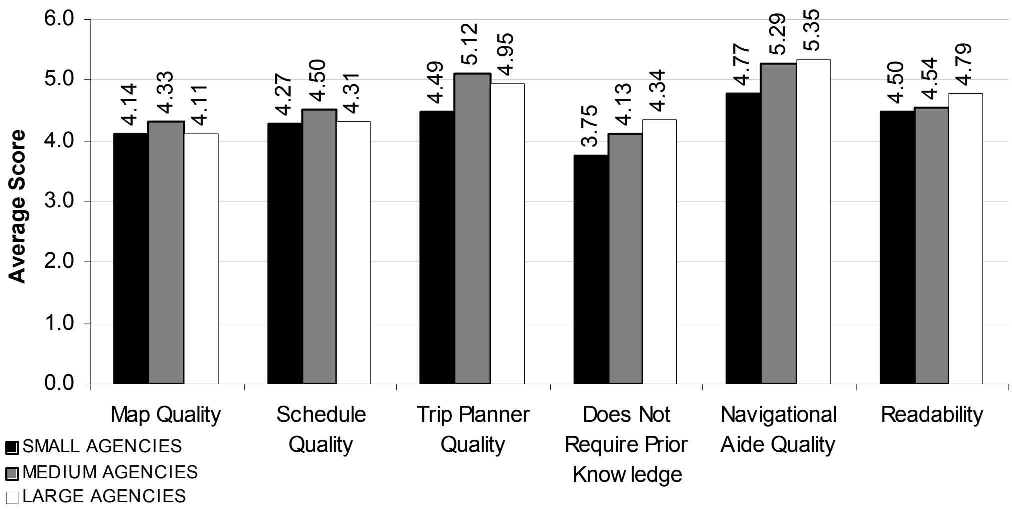

Figure 2-4 Average Scores for Internet Sites by strata (Budget)

As is apparent in Figure 2-4, there are some differences in general with respect to the presence of Internet site features between agencies classified based on ridership and agencies classified based on operating budget. While the trends are similar for measuring map and schedule quality, whether prior knowledge is required, and readability, the Internet sites of medium-sized agencies appear to receive the highest scores in map and schedule quality. This result supports the finding that there are diseconomies of scale in the quality of those kinds of information.

While the quality of trip planners tends to show diseconomies of scale to some extent, the average scores for medium and large agencies are similar to each other and are far higher than small agencies. This can be interpreted as a positive relationship between resource availability and the provision of trip planners; larger agencies above a certain level of budget are more likely to provide trip planners. From the average scores for whether prior knowledge is required, navigational aides and readability, it is apparent that the larger the agency, the higher the quality of those attributes are; so to speak, the larger the agency, the more usable Internet sites become.

Appendix 3

Table 3-1 OLS and Sample Selection Models for Map and Schedule Quality

	SCHEDULE	
	Sample Selection Model	
	Schedule Quality Coefficient (z-statistic)	**Presence of Schedule** Coefficient (z-statistic)
Constant	4.602*** (27.34)	0.554*** (2.62)
Vehicle Miles (1 million)	0.184 (0.36)	-98.361*** (-3.40)
Operating Budget (1 million)		63.872*** (4.00)
Ridership (1 million)		-63.763*** (-3.31)
Budget / Ridership	-0.078*** (-3.36)	
Squared Vehicle Miles (1 million)		
Squared Ridership (1 million)	-0.003*** (-3.09)	
N (Uncensored N)	147 (103)	
ρ	0.000	
σ	0.876	
λ	0.000	
Wald Chi^2 test	200.89***	

Wald Chi-square statistic tests all coefficients in the regression model being 0.
*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level

Table 3-2 OLS and Sample Selection Models

for Prior Knowledge Requirement and Navigational Aide Quality

	PRIOR KNOWLEDGE EQUIREMENT	
	Sample Selection Model	
	Prior Knowledge Coefficient (z-statistic)	**Presence of Site** Coefficient (z-statistic)
Constant	3.542***	-0.170
	(15.38)	(-0.47)
Vehicle Miles	4.186***	-52.085**
(1 million)	(2.63)	(-1.96)
Operating Budget		256.851***
(1 million)		(3.91)
Ridership		-263.886***
(1 million)		(-3.59)
Budget / Ridership	0.016	
	(0.61)	
Squared Vehicle	-3.702*	
Miles (1 million)	(-1.93)	
Squared Ridership		
(1 million)		
N (Uncensored N)	147 (105)	
ρ	0.000	
σ	1.127	
λ	0.000	
Wald Chi^2 test	13.45***	

*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level

Table 3-3 Probit and Sample Selection Models for Provisions of Feedback and Links

	PROVISION OF FEEDBACK		**PROVISION OF LINKS**	
	Sample Selection Model		**Sample Selection Model**	
	Feedback (yes/no)	**Presence of Site**	**Link (yes/no)**	**Presence of Site**
	Coefficient (z-statistic)	Coefficient (z-statistic)	Coefficient (z-statistic)	Coefficient (z-statistic)
Constant	-0.464**	-0.170	0.277	-0.170
	(-2.20)	(-0.47)	(1.18)	(-0.47)
Vehicle Miles		-52.085**		-52.085**
(1 million)		(-1.96)		(-1.96)
Operating Budget	-0.336*	256.851***	-0.242	256.851***
(1 million)	(-1.74)	(3.91)	(-1.26)	(3.91)
Ridership	0.346	-263.886***	0.108	-263.886***
(1 million)	(1.61)	(-3.59)	(0.44)	(-3.59)
Budget / Ridership	0.054		0.066	
	(1.56)		(1.45)	
Squared Vehicle	1.663		4.700*	
Miles (1 million)	(1.22)		(1.79)	
Squared Ridership				
(1 million)				
N (Uncensored N)	147 (105)		147 (105)	
ρ	0.000		0.000	
Wald Chi^2 test	4.870		5.23	
Pseudo R^2				
Wald Chi^2 test				

Note that selection equations in the models for having Internet site or not show identical results.
*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level

Table 3-4 Ordered Probit Model and Sample Selection Models for Map and Schedule Quality

	MAP			SCHEDULE		
	Sample Selection Model		Ordered Probit	Sample Selection Model		Ordered Probit
	Map Quality Coefficient (z-statistic)	**Presence of Map** Coefficient (z-statistic)	**Map Quality** Coefficient (t-statistic)	**Schedule Quality** Coefficient (z-statistic)	**Presence of Schedule** Coefficient (z-statistic)	**Schedule Quality** Coefficient (t-statistic)
Constant	1.434***	-0.300*	1.403***	2.157***	0.325	1.890***
Vehicle Miles (1 million)		9.127***	-1.082*	0.304	-80.570**	-0.096
Operating Budget (1 million)		0.616***			44.649***	
Ridership (1 million)	-0.015	-1.197			-35.801***	
Budget / Ridership	-0.043		-0.452	-0.832**		-0.066
Squared Vehicle Miles (1 million)	-1.378		-0.140***	-1.085		-0.011
Squared Ridership (1 million)						
N (Uncensored N)	147 (89)		89	147 (103)		103
ρ	-0.191			-0.779**		
Chi^2 test	0.414		4.515	5.113**		3.888

Chi-square statistic tests all coefficients in the regression model being 0.
*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level

Table 3-5 Ordered Probit Model and Sample Selection Models for Prior Knowledge Requirement and Navigational Aide Quality

	PRIOR KNOWLEDGE REQUIREMENT			NAVIGATIONAL AIDE		
	Sample Selection Model		Ordered Probit	Sample Selection Model		Ordered Probit
	Prior Knowledge	**Presence of Site**	**Prior Knowledge**	**Nav. Aide**	**Presence of Site**	**Nav. Aide**
	Coefficient (z-statistic)	Coefficient (z-statistic)	Coefficient (t-statistic)	Coefficient (z-statistic)	Coefficient (z-statistic)	Coefficient (t-statistic)
Constant	1.083***	-0.928	1.184***	1.971***	-0.118	2.446***
Vehicle Miles (1 million)	3.596**	-43.089	3.472**	4.112	-40.430	3.101
Operating Budget (1 million)		184.227			196.868***	
Ridership (1 million)		-187.605			-202.371**	
Budget / Ridership	0.231		0.212	-0.104**		-0.971**
Squared Vehicle Miles (1 million)	-2.571		-2.588	-4.490		-3.517
Squared Ridership (1 million)				-0.005		0.438
N (Uncensored N)	147 (105)		105	147 (105)		105
ρ	0.845			0.382		
Chi^2 test	1.950		5.433	0.316		9.780**

Chi-square statistic tests all coefficients in the regression model being 0.
*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level

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